Claims

1. A variable optical attenuator comprising:

an input/output optical system to which are connected a plurality of input optical fibers and a plurality of output optical fibers and which has a plurality of input lenses for taking beams having entered by way of said input optical fibers as input beams and a plurality of output lenses for gathering output beams to be coupled to said output optical fibers, to thereby couple said output beams to said output optical fibers;

a birefringent device provided on an output side of said input/output optical system;

a liquid crystal device capable of changing polarizing states of said input beams exiting said birefringent device; and

a reflection device which reflects beams passing through said liquid-crystal device so that the beams return to said output lens of said input/output optical system by way of said liquid-crystal device and said birefringent device.

2. The variable optical attenuator according to claim 1, wherein said input/output optical system, said birefringent device, said liquid-crystal device, and said reflection device are integrated together.

3. The variable optical attenuator according to claim 2, wherein said input/output optical system comprises

a fiber array block, in which a plurality of said input optical fibers are arranged and connected in the form of an array and a plurality of said output optical fibers are arranged and connected in the form of an array in the same direction as that in which the input optical fibers are arranged; and

a lens array block, in which a plurality of said input lenses are arranged in the form of an array in accordance with the arrangement of said input optical fibers in said input array fiber block and in which a plurality of said output lenses are arranged in the form of an array in accordance with the arrangement of said output optical fibers in said output array fiber block.

4. The variable optical attenuator according to claim 3, wherein a pitch between said input optical fibers and a pitch between said output optical fibers are set so as to become greater than a pitch between said input lenses and a pitch between said output lenses.

5. The variable optical attenuator according to claim 3, wherein said input/output optical system has

a prism unit which is interposed between said fiber array block and said lens array block and which reflects a portion of incident light in a direction crossing the direction of an optical axis; and

a light-receiving unit for monitoring input and output light which receives the light reflected from said prism unit.

6. The variable optical attenuator according to claim 5, wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each photodiode having a P electrode on one surface thereof and an N electrode on the other surface thereof, are arranged in an array pattern on a conductive transparent substrate such that said other surfaces come into contact with said transparent substrate; and wherein a common terminal of said N electrodes of said respective photodiodes are provided on said transparent substrate.

7. The variable optical attenuator according to claim 5, wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each having a P electrode on one surface thereof and an N electrode formed around said P electrodes, are arranged in the form of an array on a transparent substrate.

8. the variable optical attenuator according to claim 1, wherein said input/output optical system comprises

a fiber array block, in which a plurality of said input optical fibers are arranged and connected in the form of an array and a plurality of said output optical fibers are arranged and connected in the form of an array in the same direction as that in which the input optical fibers are arranged; and

a lens array block, in which a plurality of said input lenses are arranged in the form of an array in accordance with the arrangement of said input optical fibers in said input array

fiber block and in which a plurality of said output lenses are arranged in the form of an array in accordance with the arrangement of said output optical fibers in said output array fiber block.

9. The variable optical attenuator according to claim 8, wherein a pitch between said input optical fibers and said output optical fibers is set so as to be greater than a pitch between said input lenses and a pitch between said output lenses.

10. The variable optical attenuator according to claim 8, wherein said input/output optical system has

a prism unit which is interposed between said fiber array block and said lens array block and which reflects a portion of incident light in a direction crossing the direction of an optical axis; and

a light-receiving unit for monitoring input and output light which receives the light reflected from said prism unit.

11. The variable optical attenuator according to claim 10, wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each photodiode having a P electrode on one surface thereof and an N electrode on the other surface thereof, are arranged in an array pattern on a conductive transparent substrate such that said other surfaces come into contact with said transparent substrate; and wherein a common terminal of said N electrodes of said respective photodiodes is provided on said transparent substrate.

12. The variable optical attenuator according to claim 10, wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each having a P electrode on one surface thereof and an N electrode formed around said P electrode, are arranged in the form of an array on a transparent substrate.

13. The variable optical attenuator according to claim 1, wherein said reflection device is formed from a coupler film which permits transmission of a portion of the light exiting the liquid-crystal device; and

an input light monitor light-receiving unit for receiving the light having passed through said coupler film is provided on the surface of said coupler film.

14. The variable optical attenuator according to claim 13, wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each photodiode having a P electrode on one surface thereof and an N electrode on the other surface thereof, are arranged in an array pattern on a conductive transparent substrate such that said other surfaces come into contact with said transparent substrate; and wherein a common terminal of said N electrodes of said respective photodiodes is provided on said transparent substrate.

15. The variable optical attenuator according to claim 13,

wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each having a P electrode on one surface thereof and an N electrode formed around said P electrode, are arranged in the form of an array on a transparent substrate.

16. The variable optical attenuator according to claim 1, wherein said input/output optical system is provided with an output light monitor light-receiving unit for receiving the light that is not coupled to said output optical fiber as a result of a variation in the polarizing state of said liquid-crystal device from among the beams reflected from said reflection device.

17. The variable optical attenuator according to claim 16, wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each photodiode having a P electrode on one surface thereof and an N electrode on the other surface thereof, are arranged in an array pattern on a conductive transparent substrate such that said other surfaces come into contact with said transparent substrate; and wherein a common terminal of said N electrodes of said respective photodiodes is provided on said transparent substrate.

18. The variable optical attenuator according to claim 12, wherein said light-receiving unit is formed from a photodiode array, in which a plurality of photodiodes, each having a P electrode on one surface thereof and an N electrode formed around

said P electrode, are arranged in the form of an array on a transparent substrate.

19. The variable optical attenuator according to claim 1, wherein said liquid-crystal device has a plurality of sets, each set comprising liquid crystal and electrodes to be used for applying an electric field to said liquid crystal, for controlling a polarizing state of said liquid-crystal device for each beam exiting said input optical fibers.

20. The variable optical attenuator according to claim 1, wherein said liquid-crystal device has a plurality of sets, each set comprising liquid crystal and electrodes to be used for applying an electric field to said liquid crystal, for controlling polarizing states of the liquid-crystal device for different respective polarizing components of said input light separated by said birefringent device.

21. The variable optical attenuator according to claim 1, wherein said liquid-crystal device is formed from liquid-crystal molecules and glass plates to be used for sandwiching said liquid-crystal molecules, and said reflection device is formed on the surface of one of said glass plates.

22. A variable optical attenuator comprising:

an input optical system to which a plurality of input optical fibers are connected and which has a plurality of input lenses

that take beams exiting said input optical fibers as input beams;

a first birefringent device provided on an output side of said input optical system;

a liquid-crystal device capable of varying the polarizing states of respective input beams exiting said first birefringent device;

a second birefringent device provided on an output side of said liquid-crystal device; and

an output optical system to which a plurality of output optical fibers are connected and which has a plurality of output lenses for gathering output light exiting said second birefringent device and coupling the gathered output light to a corresponding output optical fiber.

23. The variable optical attenuator according to claim 22, wherein said input optical system, said first liquid-crystal device, said liquid-crystal device, said second birefringent device, and said output optical system are integrated together.

24. The variable optical attenuator according to claim 23, wherein said input optical system comprises

an input fiber array block in which a plurality of said input optical fibers are arranged and connected in the form of an array; and an input lens array block in which a plurality of said input lenses are arranged in the form of an array according to the arrangement of said input optical fibers provided in said input fiber array block; and

wherein said output optical system comprises

an output fiber array block in which a plurality of said output optical fibers are arranged and connected in the form of an array; and an output lens array block in which a plurality of said output lenses are arranged in the form of an array according to the arrangement of said output optical fibers provided in said output fiber array block.

25. The variable optical attenuator according to claim 22, wherein said input optical system comprises

an input fiber array block in which a plurality of said input optical fibers are arranged and connected in the form of an array; and an input lens array block in which a plurality of said input lenses are arranged in the form of an array according to the arrangement of said input optical fibers provided in said input fiber array block; and

wherein said output optical system comprises

an output fiber array block in which a plurality of said output optical fibers are arranged and connected in the form of an array; and an output lens array block in which a plurality of said output lenses are arranged in the form of an array according to the arrangement of said output optical fibers provided in said output fiber array block.

26. The variable optical attenuator according to claim 22, wherein said liquid-crystal device has a plurality of sets, each set comprising liquid crystal and electrodes to be used for

applying an electric field to said liquid crystal, for controlling a polarizing state of light exiting from said input optical fibers on a per-beam basis.

27. The variable optical attenuator according to claim 22, wherein said liquid-crystal device has a plurality of sets, each set comprising liquid crystal and electrodes to be used for applying an electric field to said liquid crystal, for controlling polarizing states of different polarizing components of said input light separated by said first birefringent device on a per-polarizing-component basis.